Appendix B
Operation of PLC Systems

B-1. Advantages of PLC System

a. General. The following operational description is typical of a lock with miter gates. Although the operational requirements may differ, locks with sector gates or lift gates can also use a PLC system.

b. Overfilling. At some locks problems exist with overfilling and overemptying of the lock chambers causing time delays and undue stress on the gates and mechanical equipment. The valves can be programmed with a PLC to start closing before the chamber is completely empty or full. The exact time when the valves begin to close could be programmed to vary with the difference between the pool and the tailwater elevations since this is what most affects the rate of filling and emptying. The speed of the valves could also be adjusted to compensate for the rate of filling and emptying at different heads. A special case could be programmed for open river conditions.

c. Improper miter/auto-emptying. Serious damage can occur to miter gates when they do not miter properly due to some obstruction or gate malfunction. If this condition occurs, it is important not to put full head on the gates. A PLC can be programmed to “crack” open the filling valves and put a small amount of pressure on the gates. If the gates do not come to a proper miter after reaching a preprogrammed head differential, the filling valves can be closed and the emptying valves opened. The operator could be given an alarm of improper miter. Such a feature is a quick programming implementation in a PLC system.

d. Lift gate control. Lift gates present special problems to navigation locks because a lift gate is hoisted from each side of the lock. The hoisting machinery has to operate synchronously to avoid skewing or “cocking” of the gate. Such fine position control and automatic skew correction can be done easily with a PLC, but would involve numerous relays, timers, and position counters in a relay system. A problem developed with the lowering of the lift gate at Melvin Price Locks and Dam. For reasons not thoroughly understood, the lift gate would occasionally get stuck in the slot. The machinery had no way of knowing that the gate had stopped. The cables continued to unreel, creating an extremely dangerous condition of the gate being suspended while the lifting cables were lying slack on the machinery room floor. While sensors had been installed on the lifting cable sheaves to detect movement, it was never considered that the sheaves could be moving when the gate was not. Special instrumentation was placed upon the gate to detect slacking of the cables. Because of the serious nature of this problem, several redundant systems were put in place. First, slack cable limit switches were installed at a horizontal run of the lifting cables, then photocells were installed in a vertical run, and, finally, angle encoders were installed to determine movement of the counterweight sheaves. In addition, it was decided to begin lowering the gate with a small amount of head against the gate. This required constant recalculation of the head differential because of the continuously fluctuating water levels. The PLC was simply reprogrammed to accommodate the changes. The lift gate at Melvin Price has a third leaf which is essentially a movable sill. This gate is raised and lowered only infrequently under certain extreme head conditions. The PLC is programmed to automatically adjust this gate during the lockage operation so as not to cause delays to traffic.

e. Voltage drop reduction. A PLC can be programmed to stagger start motors. This reduces the simultaneous inrush current, thus reducing system voltage drop during motor starting. As a result, a savings can be realized in the sizing of system power distribution equipment.

f. Troubleshooting. Troubleshooting an RBS requires that an electrician physically move from point to point and take measurements of system parameters. This can be a hazardous and time consuming procedure. A PLC system offers the convenience and efficiency of troubleshooting the system from a personal computer. Once the nature and location of the problem is identified, an electrician usually needs only to replace a modular component and the system in back online.

g. Remote troubleshooting. With a PLC system, a systems engineer or technician with a personal computer, modem, and standard phone line can network with the PLC for troubleshooting assistance and reprogramming at any time, from any place.

h. Automation. Modern PLC's are completely capable of generating the control sequences necessary to automate lock and dam operations. Currently, only the first steps have been taken in that direction.

Melvin Price Locks and Dam has a semi-automatic lockage control system in place and operational. Following is a description of the system:

(1) The operator initializes the command PREPARE UPSTREAM END FOR ENTRY/EXIT.

(2) The PLC first checks the downstream miter gates for proper miter. If the gates are not mitered, the PLC starts the miter gates and brings them to miter. The downstream traffic light automatically goes to RED.

(3) Next, the PLC checks both emptying valves to ensure they are closed. If they are not, the PLC starts the valves and closes them.

(4) The PLC now opens the filling valves and monitors the water level in the chamber for comparison to the pool elevation. Water level indication is accomplished using a submersible pressure transmitter.

(5) To prevent overfilling of the chamber, the PLC begins closing the filling valves with about a 3-ft difference between the pool and chamber elevations.

(6) When the chamber water level reaches that of the pool, the PLC lowers the lift gate or opens the miter gates.

(7) After the vessel is completely in the lock chamber and properly secured, the operator initiates the command PREPARE DOWNSTREAM END FOR ENTRY/EXIT.

(8) The PLC first closes the upstream gates.

(9) Next the PLC checks the filling valves for closure and closes them if necessary.

(10) The PLC now opens the emptying valves. The chamber is again monitored for comparison to the tailwater.

(11) When the chamber has reached the level of the tailwater, the PLC opens the downstream miter gates.

B-2. Potential Problems of a PLC System

a. Higher skill required. The design, operation, maintenance, and modification of the PLC system will require higher skill levels. Electrical engineers and technicians will require skills associated with computer circuit design, system analysis, electronic engineering, and computer programming. Lock maintenance personnel will need to be upgraded from electricians to electronics technicians. These higher skill levels require increased compensation to attract qualified candidates.

b. Commitment. The successful installation and operation of a PLC system requires management to provide top down policy direction for financial, personnel, and training resources to successfully implement this system. The successful implementation of the PLC system requires a workforce of lock operators, lock maintenance technicians, electrical engineers, and electronics technicians who are fully committed and willing to champion this concept. If these basic requirements are not satisfied, a PLC system may not live up to expectations or could even be a bug-ridden failure.